Observations of the Spatial and Temporal Variability of Wave Formed Ripples from the 2007 Martha's Vineyard RipplesDRI Experiment

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LONG-TERM GOALS

The long term goal of this work is to increase our understanding of bedform geometry and processes associated with bedforms on the continental shelf. To do this we have been developing novel measurement techniques, conducting observations of both the spatial and temporal variability of ripples and developing a variety of model approaches.

OBJECTIVES

The primary objectives of this work are:

- Measure the temporal and spatial variability of ripple geometry in wave dominated shelf environments using both stationary tripod mounted sonar systems and AUV sidescan and multibeam systems.

- Develop models to predict ripple geometry as function of hydrodynamic forcing and seafloor sediment characteristics. In particular, the models focus on increased skill in predicting ripples remaining after storms.

APPROACH

We deployed tripods with rotary sidescan and pencil beam sonars, and ADVs on two tripods in fine and coarse sand on the 8 m isobaths. These tripods were part of larger array that contained ripple measurement tripods in fine and coarse sand on the 12 and 16 m isobaths and a large array of wave sensors. We recent recovered and redeployed the tripod instrumentation and appear to have a high quality data set from the first half of the deployment. We also conducted weekly surveys with a REMUS-100 equipped with multibeam and sidescan sonars to examine the spatial variability of ripples left after wave events. In previous work (RipplesDRI04 in Florida) we used a single beam echosounder to attempt to estimate ripple heights. This required the use of an expensive and delicate inertial navigation system to estimate the vertical motion of the vehicle and still produced a noisy estimate of RMS roughness. In the 2007 experiment the vehicle was equipped with an Imagenex deltaT multibeam, which provides much better data than the echosounder (Figure 1). The multibeam does not require careful motion compensation as the ripple roughness can be quantified by band pass filtering each multibeam ping for the ripple spatial frequencies (20 cm to 2 m). Preliminary analysis of the

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tripod data has been conducted by processing the data into imagery and making movies to view the ripple temporal evolution. Processing to calculate parameters such as wavelength, height, and spectra are under way. Preliminary analysis of the REMUS data has been conducted by georeferencing the data from each survey and exporting to Google Earth to allow rapid visualization of the data on both the regional and ripple scale.

RESULTS

Rotary sidescan and pencil beam sonars: Processing of the coarse sand data has focused on developing maps of ripple topography (Figure 2) for a modeling exercise in collaboration with D.J. Tang at Univ. of Washington A.P.L. Examination of height distributions showed that for ripples with unimodal spectra the height p.d.f. is not Gaussian as commonly assumed. Tang et al had developed a technique to alert the height distribution of a simulated ripple surface from Gaussain to arcsin (blue line in Figure 2b) while preserving the spectra. Based on the data we augmented the technique to also include skewness of the height distribution, as this is typically seen in ripple elevation measurements (red line in Figure 2b). As the ripple topography becomes more complex, (e.g. bimodal spectra ripples created as a new ripple field develops over old larger ripples in response to new wave forcing) the height p.d.f. become more Gaussian.

REMUS AUV mounted multibeam and sidescan are being used to examine the spatial and temporal (weekly surveys are being conducted) and temporal variability of ripple left after wave events. This small, inexpensive multibeam will also provide a useful tool for target searching from a REMUS-100 as it covers the area directly under the vehicle which is not imaged well by sidescan sonar. This approach of using the multibeam data to fill in directly under the vehicle where sidescan does not work is now in progress of becoming available in commercially available sidescan processing software from Chesapeake Technology.

The combined tripod and REMUS data has been used to examine to evolution of cross ripples and hummocky mega-ripples in fine sand. The tripod data shows that cross ripples transitioning into medium scale irregular ripples (50 cm to 1 m wavelegth) is correlated with the formation of larger (5 m length scale and 50 cm height) hummocky mega ripple features seen in the REMUS survey data.

IMPACT/APPLICATIONS

The capability of Remus to quantify variations in bedform geometry has implications both for research and for naval operations. The system provides unprecedented combination of high resolution and large spatial coverage of seabed conditions that can be related to seabed mobility, potential for mine burial (Traykovski et al, 2005) and ability to acoustically detect mines. The combined tripod and REMUS data set appears to be ideal for testing models on the temporal and spatial variability of ripples.

RELATED PROJECTS

This project is closely related to other RipplesDRI projects such as Alex Hay's (Dalhousie) measurement of ripples on the 12 and 16 m isobaths, T. Herber's (Naval Postgraduate School) wave measurements, and Chris Sherwood's (USGS) ripple measurements on a fine-coarse sand transition.

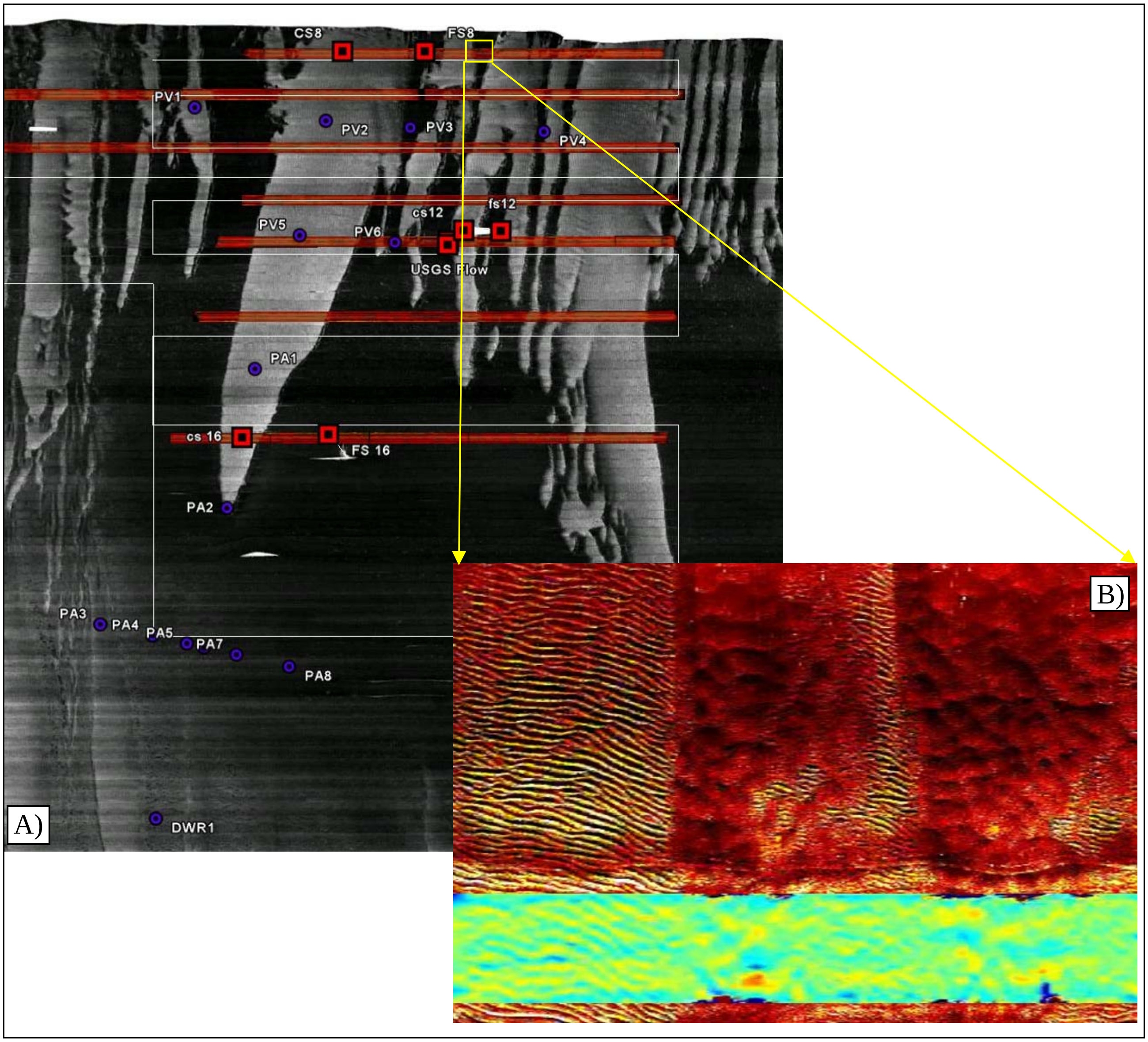

Figure 1. A) Overview of the 2007 RipplesDRI field program at the Martha's Vineyard Coastal Observatory. The background imagery is shipboard sidescan data collected by USGS just before deployment of the tripods. The coarse sand ripple scour depressions are clearly seen as the lighter bands (higher acoustic backscatter) perpendicular to the shore line. Tom Herber's (NPS) wave array is shown as blue dots, ripple measurement tripods deployed by Hay (Dalhousie), Sherwood (USGS), and Traykovski (WHOI) are shown as red squares. Sidescan data taken from a REMUS-100 is shown as orange east-west oriented lines. B) An close up of sidescan and overlapping Imagenex DeltaT data showing large orbital ripples in coarse sand and hummocky mega-ripples in fine sand.

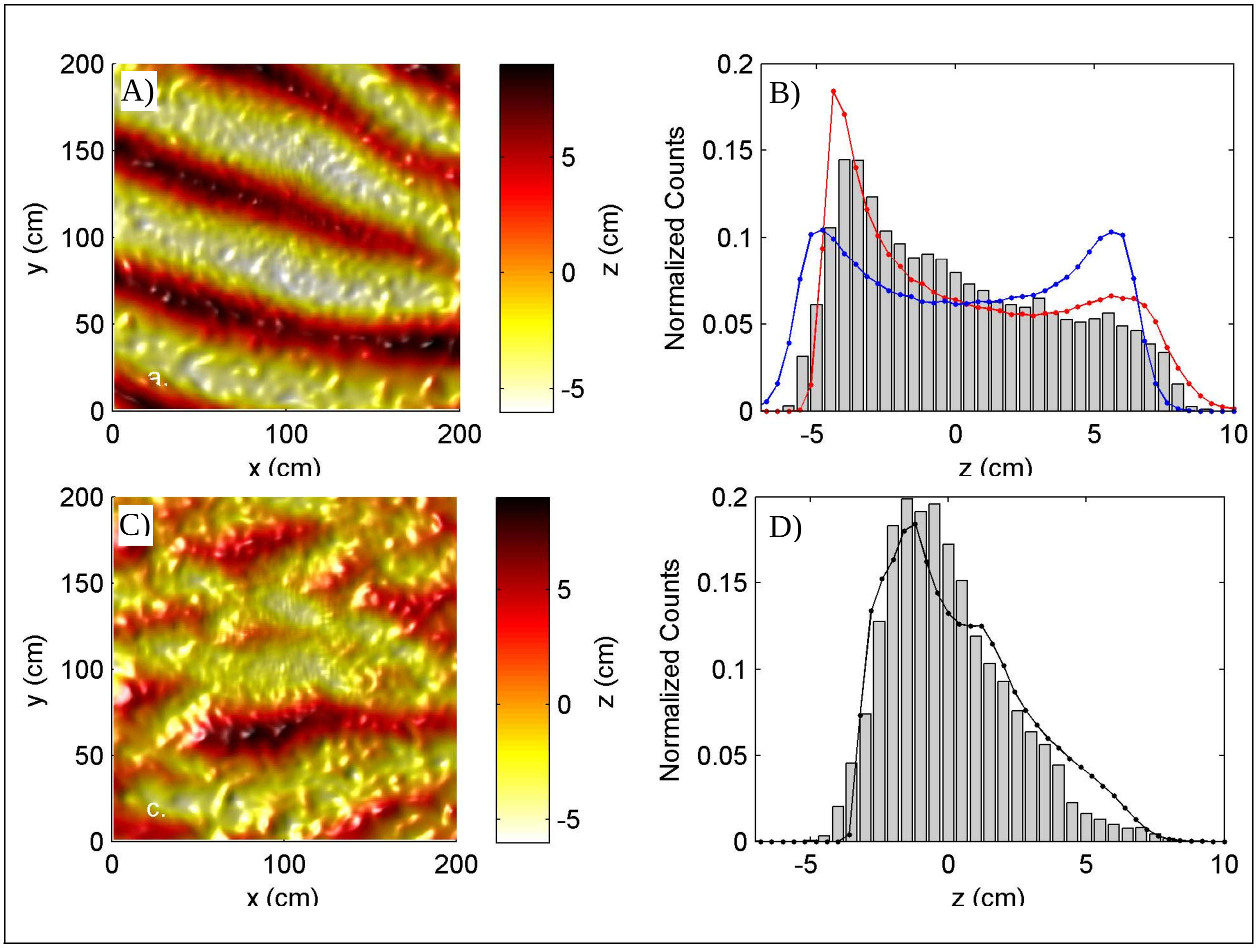

Figure 2. A) Micro-topographic maps based on 2-axis pencil beam data showing A) long-crested unimodal spectra ripples, B) the corresponding height distribution (gray bars), C) irregular bimodal spectra ripples and D) the corresponding height distribution (gray bars). Results from the Tang et al p.d.f. model for a arcsin (blue) and skewed arcsin (red) distribution are shown with the skewed arcsine fitting the data well. For the irregular ripples the model p.d.f. is adjusted to a more Gaussian shape to fit the data.

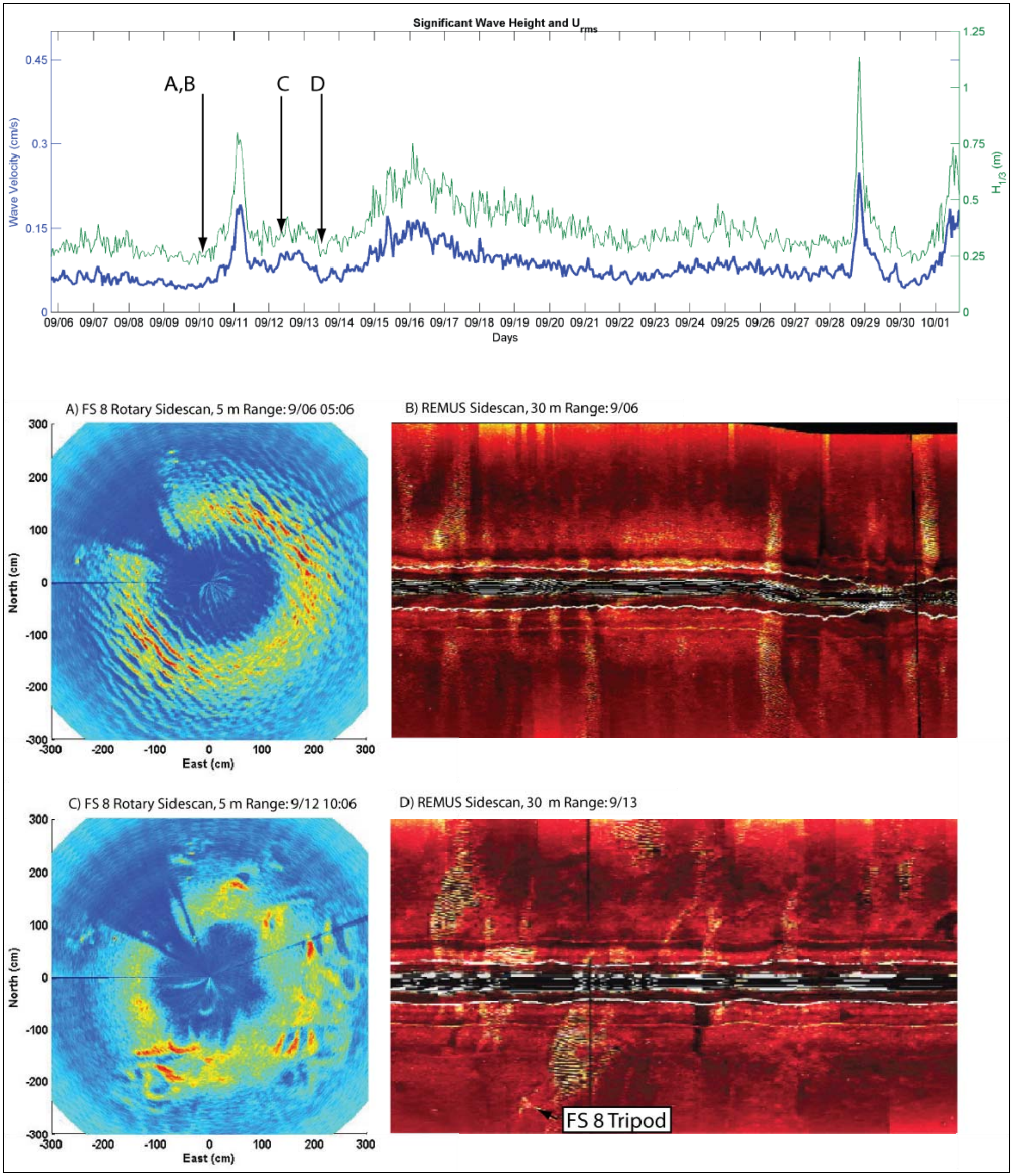

Figure 3. REMUS-100 Sidescan data taken near site FS8 (right) and tripod based Rotary fan beam data from FS8 (fine sand, 8 m depth) on 9/06 (top) and 9/12 (bottom). The shadow of the tripod is visible in the sidescan imagery. The presence of large scale hummocky megaripples in the REMUS data is correlated with the transition from cross ripples to irregular ripples in the Rotary fan beam data.

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